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# Clinical Digital Libraries Project: design approach and exploratory assessment of timely use in clinical environments\*

By Steven L. MacCall, PhD  
smaccall@bama.ua.edu  
Assistant Professor

School of Library and Information Studies  
The University of Alabama  
Box 870252  
Tuscaloosa, Alabama 35487-0252

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**Objective:** The paper describes and evaluates the use of Clinical Digital Libraries Project (CDLP) digital library collections in terms of their facilitation of timely clinical information seeking.

**Design:** A convenience sample of CDLP Web server log activity over a twelve-month period (7/2002 to 6/2003) was analyzed for evidence of timely information seeking after users were referred to digital library clinical topic pages from Web search engines. Sample searches were limited to those originating from medical schools (26% North American and 19% non-North American) and from hospitals or clinics (51% North American and 4% non-North American).

**Measurement:** Timeliness was determined based on a calculation of the difference between the timestamps of the first and last Web server log "hit" during each search in the sample. The calculated differences were mapped into one of three ranges: less than one minute, one to three minutes, and three to five minutes.

**Results:** Of the 864 searches analyzed, 48% were less than 1 minute, 41% were 1 to 3 minutes, and 11% were 3 to 5 minutes. These results were further analyzed by environment (medical schools versus hospitals or clinics) and by geographic location (North America versus non-North American). Searches reflected a consistent pattern of less than 1 minute in these environments. Though the results were not consistent on a month-by-month basis over the entire time period, data for 8 of 12 months showed that searches shorter than 1 minute predominated and data for 1 month showed an equal number of less than 1 minute and 1 to 3 minute searches.

**Conclusions:** The CDLP digital library collections provided timely access to high-quality Web clinical resources when used for information seeking in medical education and hospital or clinic environments from North American and non-North American locations and consistently provided access to the sought information within the documented two-minute standard. The limitations of the use of Web server data warrant an exploratory assessment. This research also suggests the need for further investigation in the area of timely digital library collection services to clinical environments.

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## INTRODUCTION

Timely information seeking when using collections of online resources, including medical books, is crucial if they are to be routinely consulted during patient care. A previous study shows how clinical information needs are

highly structured and points to the possibility of collection analytics that would provide a model for deep linking directly to parts of structured online resources. It also cautions about the problem of split files, a situation that arises when, for example, a clinician must use different book collections, such as MD Consult and Books@Ovid, rather than a single digital library collection of all of a library's selected online resources [1].

Any research addressing clinical information seeking must recognize the time constraints inherent in

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this work environment. Research has documented the need for timeliness in terms of clinical information seeking [2–7], with one study reporting that physicians spend on average less than two minutes pursuing answers during patient care [8]. While quality issues remain a problem [2], a growing amount of research addresses the use of online resources [9–15]. Health sciences librarians are well suited to address the problems of information quality through extending collection development practices to collections of online resources [16]. The challenge facing librarians is whether their digital library collections can be organized so that they can be used for clinical information seeking in a timely way.

This paper describes the Clinical Digital Libraries Project (CDLP) and its approach to providing access to information at a level of granularity that addresses the structural aspects of clinical information seeking, while also dealing with the problem of split files. An exploratory quantitative evaluation that evaluates the CDLP approach in terms of timeliness is presented.

## BACKGROUND INFORMATION

Several issues impact timely information seeking when using online resource collections. First, the Web is a large and complex information resource. For example, the Web-accessible bibliographic records of PubMed MEDLINE number more than twelve million [17]. In addition to this massive information repository, the advent of the Web has facilitated the online publication of additional types of resources. These include online medical books with known quality, such as *Harrison's Principles of Internal Medicine* and the MD Consult textbook collection, and new peer-reviewed resources, such as E-Medicine. These join the many other resources on the Web to produce a total number of Web pages that is estimated by several search engine companies to be more than three billion [18]. Third, complicating the problem of overabundance is growing pressure from the preventive medicine and consumer health communities that have made the case for tailored information packages for patients [19] and for "information therapy" [20, 21]. These new opportunities for prescribing information hold the promise of improving patient compliance and overall well-being [22], if readability levels are appropriate for patients [23], but they add to the problem of timely information seeking using online resource collections, especially during patient care.

Systems for information retrieval that contain or point to pertinent information and are easy to use are the twin answers to the question of how to facilitate timely information seeking during patient care [24]. One example that predates the Web is the book collection. Medical books contain clinically pertinent information and have indexes to facilitate the systematic seeking of specific information within their covers. Book indexes serve as random-access mechanisms that enable individuals to go directly to the specific information that they need, preventing the need for scan-

ning entire books [25]. Though problems of use efficiency [26] and indexing imprecision [27] exist, the ubiquity and consistent structuring of book indexes represent important parts of the architecture for systematically seeking specific information across individual books in a collection. Put another way, book indexes instantiate a "part specification plan" [6] that frames access to specific information. For example, a clinician can employ an identical information-seeking method when using the indexes to *Harrison's Principles of Internal Medicine* and *Mandell: Principles and Practice of Infectious Diseases* to locate specific information on the laboratory diagnosis or treatment of botulism. The lack of consistent structuring across online resources is an obstacle to their timely use [28]. In studies of the use of online resources, this lack of consistent structuring has been shown to cause excessive scrolling through and printing of long Web pages [29].

The overabundance of online resources coupled with a lack of structural consistency subjects clinicians to inevitable difficulties finding timely clinical information during patient care. One way to consider the problem of online resource use is as two separate search tasks: (1) inter-site search, defined as finding a particular online resource, and (2) intra-site search, defined as finding specific information *within* the retrieved resource. The first task is typically accomplished with the use of automatically indexed search engines or the use of human-constructed directories. The second task is more complex due to the idiosyncratic and inconsistent intra-site structuring across online resources [30]. Thus, for timely clinical information seeking using online resource collections, a part-specification plan is needed that would provide consistent intra-site structuring across online resources in a collection. Physical libraries facilitate this because of the consistent books indexes in their book collections. Can the library community replicate this architecture by providing consistent structuring in their digital library collections of online resources?

## CLINICAL DIGITAL LIBRARIES PROJECT DIGITAL LIBRARY COLLECTION DESIGN

The CDLP—a research, service, and teaching project of the schools of library and information studies at the University of Alabama and the University of North Texas—investigates a model for large-scale highly indexed resource collections for clinical information seeking [31]. Currently, the CDLP provides services to 20 institutions and receives as many as 1,000 daily referrals from individuals using one of the many public search engines, such as Google, to search for medical information. Many users originate searches from medical schools and hospitals across the United States and around the world.

Three library practices underpin the CDLP digital library (DL) collection design. First, the linked resources are high quality because they have passed a quality check by CDLP investigators prior to being included in the DL collections. This quality check is in keeping

**Figure 1**  
Pathology subsection for clinical topic page "Histoplasmosis"

*Pathology Resources*

- Harrison's Principles of Internal Medicine, 15th ed., 2001: [Table of contents: Health Sciences Library subscription \(INFO\)](#)
  - Chapter 201: Histoplasmosis: [Table of contents](#)
    - Etiologic Agent: [Access document](#)
    - Pathogenesis, and Pathology: [Access document](#)
    - Diagnosis: [Access document](#)
- Mandell: Principles and Practice of Infectious Diseases, 5th ed., 2000 (MD Consult): [Table of contents: Health Sciences Library subscription \(INFO\)](#)
  - Chapter 254: *Histoplasma capsulatum*: [Access document](#)
    - Ecology and Epidemiology: [Access document](#)
    - Mycology: [Access document](#)
    - Pathogenesis: [Access document](#)
- Rakel: Conn's Current Therapy, 55th ed., 2003 (MD Consult): [Table of contents: Health Sciences Library subscription \(INFO\)](#)
  - Chapter 69: Histoplasmosis: [Access document](#)
    - Diagnosis: [Access document](#)
- Cotran: Robbins Pathologic Basis of Disease, 6th ed., 1999 (MD Consult): [Table of contents: Health Sciences Library subscription \(INFO\)](#)
  - Chapter 9: Infectious Diseases: [Access document](#)
    - General Principles of Microbial Pathogenesis: [Access document](#)
    - Respiratory Infections: [Access document](#)
- Ravel: Clinical Laboratory Medicine, 6th ed., 1995 (MD Consult): [Table of contents: Health Sciences Library subscription \(INFO\)](#)
  - Chapter 16: Mycotic Infections: [Access document](#)
    - Systemic Mycoses: [Access document](#)
    - Fungal Cultures: [Access document](#)
- Internet Pathology Lab for Medical Education (FSU Coll of Med): [Table of contents](#)
  - Infection: [List of documents](#)
    - *Histoplasma capsulatum* Granulomas, Liver, Gross: [Access document](#)
    - *Histoplasma capsulatum*, Microscopic: [Access document](#)
    - *Histoplasma capsulatum*, PAS Stain, Microscopic: [Access document](#)
- eAtlas of Pathology (University of Connecticut): [Table of contents](#)
  - Diseases of Lung: [List of documents](#)
    - Histoplasma Infection of Lung (GMS Stain 40X): [Access document](#)
    - Granuloma in Lung (4X): [Access document](#)
    - Granuloma in Lung (10X): [Access document](#)
    - Granuloma in Lung (20X): [Access document](#)

with the collection development policy approach of health sciences libraries' print collections [16]. Second, the high-quality resources in CDLP DL collections include those from the "invisible Web" in that they are subscription-based databases of full-text resources that are restricted to authorized users and are not indexed by typical Web search engines [32]. Examples of these resources include Harrison's Online and MD Consult. Purchasing access to these resources for constituents involves the library practice of managing budgets of knowledge resources for the library's parent institution [16].†

The third practice underpinning the CDLP DL collection design extends the collocating objective [33] of physical library organization to digital library collections. In the context of library science, collocation is the bringing together of like items according to an established criterion. In the case of the organization of books on the typical health sciences library's shelves, this criterion is the topicality represented by the National Library of Medicine's classification. This library practice provides the basis for bibliothecal access in the form of a classified shelf arrangement of books in a coherent, useful, and publisher-independent way. In the CDLP DL collection design, the collocating objective uses the library criterion of topicality. However, because the DL collections organize links rather than books, a finer level of granularity is possible for collocating the structural components of resources, such

† In the Clinical Digital Libraries Project model, those libraries without Harrison's and/or MD Consult licenses would not have links to those resources in their clinical digital libraries.

**Table 1**  
Profile of Clinical Digital Libraries Project (CDLP) digital libraries

Attribute	Number
Clinical topic pages in each digital library	1,107
Topical subsections in each digital library	7,482
Average subsections per clinical topic page	6.75
Resource links (estimate) in each digital library	101,190
Average number of resource links per clinical topic page	91.4

as the chapter sections of various books, according to a specific publisher-independent classification scheme. Meeting the collocating objective in this way allows the DL collections to contain a consistent set of links providing deep access to structured clinical resources independent of publisher, thus avoiding the problem of split files. The "Pathology" topical subsection for the clinical topic "Histoplasmosis" is presented as an example of the CDLP collection design in Figure 1.

Each DL collection evaluated in this study contained 1,107 consistently structured clinical topic pages, which were further subdivided into 7,482 topical subsections (mean, 6.75) and an estimated 101,190 resource links (mean per clinical topic, 91.4) (Table 1). A full CDLP DL may be viewed online at <http://cchs-dl.slis.ua.edu>.

## METHODS

### Design

Web server log activity of 6 CDLP DLs was retrospectively studied over a 12-month period (7/2002 to 6/2003) for evidence of timely use. The 6 DLs were selected because their collections contained nearly identical link content, including links to book chapters and chapter sections in Harrison's Online and the 37 textbooks maintained by MD Consult, as well as links to other high-quality online resources. Because all 1,107 clinical topic pages in each DL collection were rendered in static hypertext markup language (HTML), they had been captured and indexed by the spidering software of major search engines, including those used by searchers in this study (Table 2). As a result, all 6,642 ( $6 \times 1,107$ ) clinical topic pages were available worldwide during the time period of the study to anyone via the keyword search of those search engines. This provided the opportunity to evaluate the timeliness of CDLP DL users' searches after they were referred to one of 6,642 CDLP clinical topic pages by a search originating with a search engine query. Timeliness was determined based on a calculation of the

**Table 2**  
Search engines used by searchers in sample

Google
Yahoo Search
MSN Search
Ask.com (AskJeeves.com)
Alta Vista
AlltheWeb
Teoma

**Table 3**

Example searches that meet information-seeking criteria as recorded by CDLP Web server log

Search "hit" sequence	Outcome as indicated by CDLP Web server log
1	<a href="http://www.google.com/search">http://www.google.com/search</a>
2	<a href="http://cchs-dl.slis.ua.edu/clinical/infectious/byorganism/fungal/histoplasmosis.htm">http://cchs-dl.slis.ua.edu/clinical/infectious/byorganism/fungal/histoplasmosis.htm</a>
3	<a href="http://harrisons.accessmedicine.com/server-ava/Arknoide/amed/harrisons/co_chapters/ch201/ch201.p03.html">http://harrisons.accessmedicine.com/server-ava/Arknoide/amed/harrisons/co_chapters/ch201/ch201.p03.html</a>
4	<a href="http://home.mdconsult.com/das/book/view/883/2171.html/top/">http://home.mdconsult.com/das/book/view/883/2171.html/top/</a>
5	<a href="http://www-medlib.med.utah.edu/WebPath/INFEHTML/INFE031.html">http://www-medlib.med.utah.edu/WebPath/INFEHTML/INFE031.html</a>

difference between the timestamps of the first and last Web server log "hit" during each search in the sample. The calculated differences were mapped into 1 of 3 ranges: less than 1 minute, 1 to 3 minutes, and 3 to 5 minutes.

### Sample

The convenience sample for this study consisted of all searches referred from search engines to CDLP clinical topic pages during a one-year period (7/2002–6/2003) that met information-seeking criteria and originated in medical education or hospital or clinic environments from North American and non-North American locations as reflected in the CDLP Web server log. The establishment of information-seeking criteria, discussed below, was necessary to form a sample of users, because the nature of CDLP log files data collection did not permit sampling by any other means.

**Information-seeking criteria.** During the time period, referred search engine searches were judged to reflect either information-seeking or information-gathering activities. Information seeking was defined as an activity undertaken to satisfy a perceived need, usually for a specific problem [34]. To simulate information seeking in the time constraints of the clinical environment, searches of five or fewer minutes were considered information seeking and were included in the sample. Searches of greater than five minutes were considered information gathering and were not included in the sample. The five-minute cutoff was based on the traditional time allotment for clinical information seeking as exemplified by the 5-Minute Clinical Consult series of reference books. Further, only those searches logged as six or fewer "hits" were considered information seeking and were included in the sample. Searches with seven or more hits were judged to be information gathering. With this sample, the author was able to evaluate the distribution of search times over a three-part range (less than 1 minute, 1–3 min-

utes, and 3–5 minutes) to determine whether the CDLP DLs facilitated timely clinical information seeking.

Table 3 illustrates a search meeting information-seeking criteria as recorded by the CDLP Web server log. In this example, the DL user: (1) was referred to the CDLP Web server by a Google search query; (2) retrieved one of the CDLP DL clinical topic pages on histoplasmosis; (3) followed the DL link to specific information on the pathology and pathogenesis of histoplasmosis from section 3 of chapter 201 ("Histoplasmosis") from Harrison's Online; (4) followed the DL link to specific information on the pathogenesis of histoplasmosis from page 2171 of chapter 254 ("*Histoplasma capsulatum*") from MD Consult textbook #883, *Mandell: Principles and Practice of Infectious Diseases*; and (5) followed the DL link to a specific pathology slide of *Histoplasma capsulatum* provided by the Internet Pathology Lab for Medical Education at the Florida State University College of Medicine (slides are hosted on a Web server at the University of Utah). The difference between the timestamps of the first and fifth log server "hit" in this example was less than five minutes.

**Institutional environment and geographic location of searches meeting information-seeking criteria.** To identify the institutional environment and geographic location of searches meeting information-seeking criteria, a filter table was created with a subset of the total CDLP users data set. To generate the filter table, Internet protocol (IP) addresses were decoded by hand using IP tracing software (GeekTools Whois) to determine the institutional environment and geographic location from which each CDLP user originated searches. The filter was then run against the entire twelve-month period of searches meeting information-seeking criteria to generate the sample. The institutional origin of searches in the sample is summarized in Table 4.

### Limitations

The distributed nature of the Web prevents a definitive study of user motives and outcome satisfaction, especially when drawing from users around the world. The above methodology attempts to control for these unknowns by applying what is known in the clinical information-seeking literature, specifically pertaining to the time that physicians allow for information retrieval, to the Web environment. Thus, the quantitative results discussed below must be viewed as preliminary. Further qualitative research is also necessary to determine how *satisfied* individual DL collection users were

**Table 4**

Institutional and geographic origin of searches

Search origination category	Institutions in IP filter for sample (N = 431)	Searches in sample (N = 864)
North American hospitals or clinics	221 (51%)	403 (47%)
Non-North American hospitals or clinics	17 (4%)	84 (10%)
North American medical schools	110 (26%)	237 (27%)
Non-North American medical schools	83 (19%)	140 (16%)

**Table 5**  
Search session lengths

Session length	Searches (N = 864)
Less than 1 minute	415 (48%)
1–3 minutes	350 (41%)
3–5 minutes	99 (11%)

with the information retrieved during searches. However, the satisfaction question was mitigated in part because of the quality control inherent in the CDLP DL design, which only provided access to collections of selected high-quality online resources.

Another limitation of this study concerned the use of a Web server log as the data source. The distributed nature of the Web precluded verification of user activity by direct observation. The large sample size of this study in part mitigated this concern. Also, the manual decoding of the IP addresses to identify the institutional origin of searches increased confidence in the assumption that information-seeking activity was clinically related. However, follow-up studies are necessary to replicate the findings of this research, especially studies that include direct observation of clinical users.

## RESULTS

### Sample characteristics

Eight hundred sixty-four searches met the information-seeking criteria included in the sample for this study. Table 4 shows the number of searches performed in each of the 4 CDLP user categories. North

American hospitals or clinics were represented by 221 institutions (51%) and 403 searches (47%) in the sample. Non-North American hospitals or clinics were represented by 17 institutions (4%) and 84 searches (10%) in the sample. North American medical schools were represented by 110 institutions (26%) and 237 searches (27%). Of the 110 medical schools, 109 were members of the American Association of Medical Colleges and 1 was a member of the American Association of Colleges of Osteopathic Medicine. Non-North American medical schools were represented by 83 institutions (19%) and 140 searches (16%).

### Outcome measures

Data were analyzed for three time intervals: less than one minute, one to three minutes, and three to five minutes. Of concern was the distribution of timeliness measures across the three intervals to determine whether the CDLP DLs facilitated timely clinical information seeking.

**Search summary performance.** Of the 864 total searches, 415 (48%) were less than 1 minute, 350 (41%) were 1 to 3 minutes, and 99 (11%) were 3 to 5 minutes (Table 5).

**Searches by institutional environment.** Table 6 shows that of the 377 searches originating from medical schools, 175 (46%) were completed within 1 minute and 157 (42%) were completed in 1 to 3 minutes. Of the 487 searches originating from hospitals or clinics, 240 (49%) were completed within 1 minute and 193 (40%) were completed in 1 to 3 minutes. There was no

**Table 6**  
Data on CDLP digital library use

Variable	Time taken for searches			P value
	< 1 minute	1–3 minutes	3–5 minutes	
Searches by institutional environment				
Hospitals or clinics	240/487 (49%)	193/487 (40%)	54/487 (11%)	0.70
Medical schools	175/377 (46%)	157/377 (42%)	45/377 (12%)	
Searches by geographic location				
North America	318/640 (50%)	255/640 (40%)	67/640 (10%)	0.15
Non-North American	97/224 (43%)	95/224 (42%)	32/224 (14%)	
Searches by location and environment				
North American hospitals or clinics	197/403 (49%)	163/403 (40%)	43/403 (11%)	0.28
Non-North American hospitals or clinics	43/84 (51%)	30/84 (36%)	11/84 (13%)	
North American medical schools	121/237 (51%)	92/237 (39%)	24/237 (10%)	
Non-North American medical schools	54/140 (38%)	65/140 (46%)	21/140 (15%)	
Searches by month				
7/2002	14/38 (37%)	19/38 (50%)	5/38 (13%)	0.03
8/2002	22/49 (45%)	22/49 (45%)	5/49 (10%)	
9/2002	22/59 (37%)	26/59 (44%)	11/59 (19%)	
10/2002	25/52 (48%)	24/52 (46%)	3/52 (6%)	
11/2002	22/39 (56%)	12/39 (31%)	5/39 (13%)	
12/2002	37/75 (49%)	33/75 (44%)	5/75 (7%)	
1/2003	92/220 (42%)	101/220 (46%)	27/220 (12%)	
2/2003	39/88 (44%)	36/88 (41%)	13/88 (15%)	
3/2003	50/71 (70%)	14/71 (20%)	7/71 (10%)	
4/2003	34/60 (56%)	20/60 (33%)	6/60 (10%)	
5/2003	29/63 (46%)	28/63 (44%)	6/63 (12%)	
6/2003	29/50 (58%)	15/50 (30%)	6/50 (12%)	

significant difference ( $\chi^2 = 0.709$ ,  $P = 0.70$ ) across time taken for each search by institutional environment, thus indicating timely information seeking by CDLP collection users regardless of their institutional environment.

**Searches by geographic location.** Table 6 shows that of the 640 searches originating from North American locations, 318 (50%) were completed within 1 minute and 225 (40%) were completed in 1 to 3 minutes. Of the 224 searches originating from non-North American locations, 97 (43%) were completed within 1 minute and 95 (42%) were completed in 1 to 3 minutes. There was no significant difference ( $\chi^2 = 3.787$ ,  $P = 0.15$ ) across time taken for each search by geographic location, thus indicating timely information seeking by CDLP users regardless of their geographic locations. The fact that the CDLP collections are in English did not significantly impact the distribution of search times.

**Searches by institutional environment and geographic location.** Table 6 shows that, of the 403 searches originating from North American hospital or clinic environments, 197 (49%) were completed within 1 minute and 163 (40%) were completed in 1 to 3 minutes. Of the 237 searches originating from North American medical schools, 121 (51%) were completed within 1 minute and 92 (39%) were completed in 1 to 3 minutes. Of the 84 searches originating from non-North American hospitals or clinics, 43 (51%) were completed within 1 minute and 30 (36%) were completed in 1 to 3 minutes. Of the 140 searches originating from non-North American medical schools, 54 (38%) were completed within 1 minute and 65 (46%) were completed in 1 to 3 minutes. Only in the non-North American medical schools were 1-to-3-minute searches more numerous than less-than-1-minute searches. However, despite this outcome, there was no significant difference ( $\chi^2 = 7.465$ ,  $P = 0.28$ ) across time taken for each search by institutional environment and geographic location when considered together, thus indicating timely information seeking by CDLP users regardless of their institutional environment and geographic location.

**Searches by time period.** Table 6 shows the timeliness of CDLP DL searches on a month-by-month basis during the period of the study. Though the results were not consistent on a month-by-month basis over the entire time period, data for eight of twelve months showed that less-than-one-minute searches predominated and data for one month showed an equal number of less-than-one-minute and one-to-three-minute searches.

## DISCUSSION

The results of this exploratory assessment showed that CDLP collections facilitated timely information seeking for users in medical education and hospitals or

clinics from North American and non-North American locations after they were referred to CDLP DL clinical topic pages from Web search engines. Additionally, the prevalence of less-than-one-minute searches indicated the possibility that DL collections could be used to meet the two-minute standard for clinical information seeking [8], regardless of institutional environment and geographic location when these factors were considered separately and when considered together. Though the results were not consistent on a month-to-month basis over the entire period of the study, data for eight of twelve months showed that less-than-one-minute searches predominated and data for one month showed an equal number of less-than-one-minute and one-to-three-minute searches. Follow-up qualitative studies are now needed to replicate these findings and to verify user satisfaction with retrieved information.

At first glance, these timeliness results would seem replicable by any collection linking directly to structured online resources. The CDLP collection design, however, applies consistent deep linking that provides access to specific clinical information *within* structured online resources on a large scale. This approach results in DL collections that are massively pre-linked information spaces and provide numerous paths for users to efficiently follow to specific clinical information. Further, as is the case with physical libraries, the CDLP collection design is a resource-independent approach because it displays the online resources of any publisher in a way that standardizes their appearance at a level of collocative granularity that promotes timely information seeking. Table 3 exemplifies standardized cross-publisher information retrieval.

## CONCLUSION AND FUTURE DIRECTION

The CDLP collections provide timely access to the specific clinical information contained in high-quality online resources when used during information seeking in medical education and hospitals or clinics from North American and non-North American locations. The limitations inherent in the use of Web server data, however, warrant tentative conclusions that require follow-up investigation.

Preliminary work for the next generation software environment for the CDLP DL collections has been completed by the Digital Libraries Navigation Lab at the University of Alabama <<http://dlaws.slis.ua.edu>> with assistance from WebSphere specialists at IBM. Future support for Web services will make it possible to fulfill the integrative possibilities of the CDLP DL collections, including the long-standing goal of integrating relevant knowledge-based information resources into electronic medical records (EMRs) [35, 36]. Future research and software development at the University of Alabama will center on connecting CDLP DLs and EMRs through the use of the Infobutton Application Programming Interface, which is currently under Health Level 7 (HL7) standards review.

The infobutton is a point-of-care information retrieval application that automatically generates and sends queries to online resources using patient data extracted from the EMR [37]. The new CDLP software environment would enable DL collections to accept infobutton-generated queries and subsequently return subsections of clinical topic pages indexed to meet specific topical criteria, including age-related patient demographics. Implementing the infobutton would connect clinicians to their institution's DL collection that contains links to both subscription-based and high-quality free resources managed by health sciences librarians. The research results presented in this paper indicate that CDLP collections can facilitate timely clinical information seeking by users in medical education and hospitals or clinics after they are referred from Web search engines. Additional research would be necessary to determine whether this timeliness is replicated after users are referred by EMR infobutton use during clinical care.

EMRs are an especially important integration opportunity for health sciences librarians, clinicians, publishers, and EMR vendors. For example, if a clinician were working up a particular clinical case and the EMR suggested several possible diagnoses, an HL7-compliant infobutton would provide access to the subsections of clinical topic pages with links to resource components that are managed, and often purchased, by the health sciences library of the clinician's institution. In this scenario, the health sciences library continues to serve as the clinician's agent to select, purchase, and organize consistently structured collections of high-quality resources. This scenario benefits publishers in that their online resources can be easily inserted into the everyday clinical decision-making environment that is the EMR. EMR vendors benefit by not having to make separate agreements with individual online resource publishers but would have a standard method for accessing online resource collections that are actively managed by professional health sciences librarians.

When considered as a whole, the existing network of health sciences libraries—from the largest in academic health sciences centers to the smallest in hospital environments—provides an array of professional services to the medical community including selecting, purchasing, and organizing high-quality clinical resource collections. This research seeks to leverage this network by enabling librarians to extend their professional practices to DL collections by using consistently structured deep-linking methods that promote timely use under the time constraints of the clinical environment.

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